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Warsaw Pact Communications Switching (U)

A Defense Intelligence Report

Defense Intelligence Agency

DST-2610R-435-86
5 December 1986

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WARSAW PACT COMMUNICATIONS SWITCHING (U)

Authors:

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PREFACE (U)

(S-NF) This study is comprised of four sections which are intended to provide a summary of the Warsaw Pact communications switching capability. The first section provides a background on switching systems. Section II details the switching goals and plans of the Warsaw Pact nations. Given the high-priority recently placed on upgrading their telecommunications infrastructure, and the limitations of Warsaw Pact indigenous production, technology transfer will play an increasing role in meeting their goals. Section III details current Warsaw Pact switching technology, and Section IV puts future technology transfer requirements of the Warsaw Pact into perspective.

(S-NF) Although this report addresses Warsaw Pact switching systems, the Soviet Union has been used in many examples because they are the driving force behind the telecommunications upgrade throughout the Warsaw Pact countries.

(U) Appreciation is extended to Lt Veronin, FTD/TQCT, for his extensive editing and important contributions to this study. Also, appreciation is expressed to Mrs Nadine Warner for editing of the study.

(U) Suggestions for revision of the technical information or assessments contained in this short paper, constructive criticism and comments are welcome. Such suggestions and appropriate references should be forwarded to the Defense Intelligence Agency, Attn: DT-4, Washington DC 20301-5000.

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SUMMARY (U)

(S) Telecommunication goals and objectives of Warsaw Pact countries indicate plans to install (post-2000) an integrated services digital network (ISDN). In the nearer term (1986-1990), the beginnings of an integrated digital network (IDN) can be economically realized by installing modern digital multiplexing systems interfaced with existing analog transmission systems. The IDN will utilize stored program controlled (SPC) switching, digital multiplexing, and eventually fiber optic transmission systems. The speed with which the Warsaw Pact is able to transition toward an IDN is directly dependent on their ability to acquire SPC switching systems through external purchase and internal manufacture.

(S-NF) Warsaw Pact countries, especially the USSR, have placed a high priority on the purchase of digital, time division, SPC switches from Western Europe and Japan. The installation of state-of-the-art switching systems affords a very cost effective means of upgrading large telecommunications systems. SPC switching provides great flexibility in large-scale rerouting of traffic by allowing changes in switching priorities and protocols to be easily accomplished through software. Acquisition of this increased flexibility will significantly improve Warsaw Pact command, control, and communication (C^3) systems.

(S-NF) Current COCOM restrictions on the sale of SPC switching technology to the Warsaw Pact are scheduled to be automatically relaxed and will be reviewed by 15 September 1988. These trade restrictions have had some effect in slowing the Warsaw Pact's realization of their telecommunications goals. A renewal of these restrictions for another 5 to 7 years would be a blow to Warsaw Pact C^3 capabilities in the 1990's and beyond. While the above restrictions have been effective in curbing the Warsaw Pact's C^3 upgrade, current and additional controls in four areas would further delay their plans:

-- (C) Control of small-to-medium SPC switch production technology.*

-- (C) Maintaining or strengthening the current controls on microelectronic device production.

-- (C) Consideration of new controls on digital private automatic branch exchange (PABX) systems.

-- (C) Maintain control over enhanced features for SPC (e.g., common-channel signaling, preemption).

Soviet and Warsaw Pact plans for a diverse, high-capacity, survivable telecommunications infrastructure cannot be met without the installation of large numbers of small-to-medium SPC switches (10,000 to 30/45,000 lines).* While current COCOM controls on large SPC switches (above 50,000 lines) have impacted Soviet plans, their greatest need is for small-to-medium transit switches. In addition to these systems, more controls on PABXs would slow Soviet progress. Modern PABX systems are small and powerful, and the potential for the dual use of such systems in military applications is high.

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Soviet progress. Modern PABX systems are small and powerful, and the potential for the dual use of such systems in military applications is high. Widespread use of these systems in the Warsaw Pact could also significantly reduce the loading of local exchanges and therefore release resources for higher level applications.

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*(U) This report uses a consistent set of reasonable line and trunk capacities to differentiate between switch sizes because there are no standard sizes. This allows for the important distinction between switches which require marginal computing power and simple programs, and intelligent switches, which require significant computing power and sophisticated programs.

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SECTION I

BACKGROUND (U)

1. Introduction (U)

(U) Digital, time division, stored program controlled (SPC) central office circuit switching systems are being installed in telephone networks around the world. A variety of SPC systems are being marketed by major manufacturers, including the L. M. Ericsson AXE systems from Sweden, the Siemens System EWSD from West Germany, Alcatel systems from France, Northern Telecom systems from Canada, ITT's 1240 system, AT&T's ESS system, and Japan's NEC NEAX-61 system. These systems are the latest development in switching equipment for national telephone networks.

(U) The Soviet Union and several East European countries have sought to purchase SPC switching systems and related manufacturing technology for use in their "public" telephone networks. These switches improve their communications facilities and thereby enhance the command, control, and communications (C^3) capabilities of the Warsaw Pact (WP) armed forces. Although SPC switching systems use leading-edge microcircuit technology, they have been subject to inconsistent Coordinating Committee (COCOM) treatment in the past.

(U) At least seven major telecommunications manufacturers, including two non-COCOM-based companies, produce digital SPC systems for the world market. Some of these manufacturers also have licensed companies in non-COCOM countries to make their products. In many contracts, the purchaser has required local manufacturing and/or assembly as a condition of the purchase. This information suggests that more countries are developing the capability to manufacture digital SPC systems even though COCOM controls are being made more restrictive. In addition, advanced developing countries, such as South Korea and Brazil, are developing their own technologies.

2. Switching Terms (U)

(U) Switching systems allow for the on-demand interconnection of a large number of telephones. Without switching, all telephones in a given network would be permanently connected to every other telephone in the network. This "fully meshed" network would require unmanageable numbers of lines. As shown in Figure 1, switching systems reduce the number of lines between telephones. The application of switching systems in layers further reduces the number of lines as shown in the two-level switched network in Figure 1. Figure 2 shows the five levels of switching offices used in the US. This hierarchical arrangement is necessary for achieving efficient telephone networks over large geographical areas. Figure 3 shows the relationship of private branch exchanges (PBX) to a national network. These privately owned systems essentially provide another layer of switching in the national telecommunications infrastructure.

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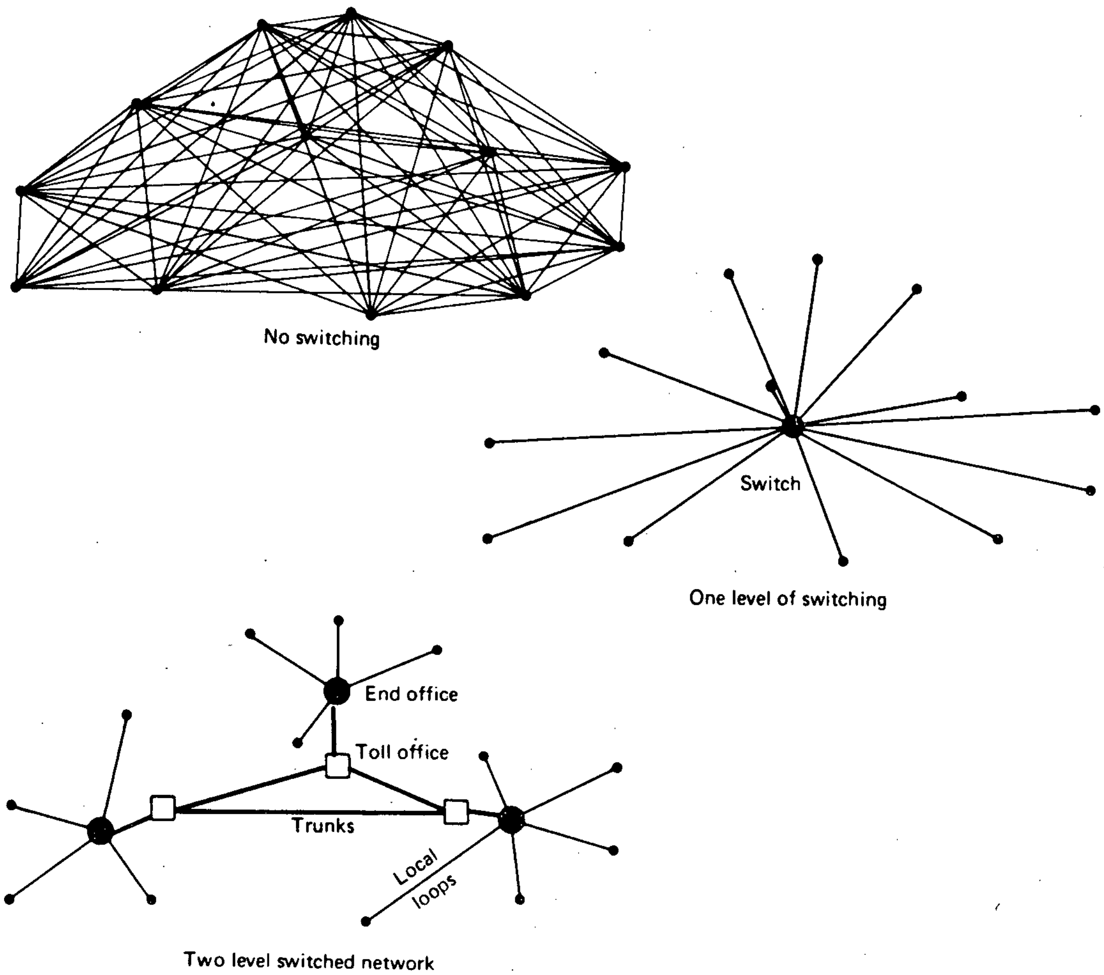

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Figure 1. (U) Levels of Switching and Line Reduction

(U) NOTE: Figures 1, 2, and 3 are from "Telecommunications and the Computer," by James Martin, 1976.

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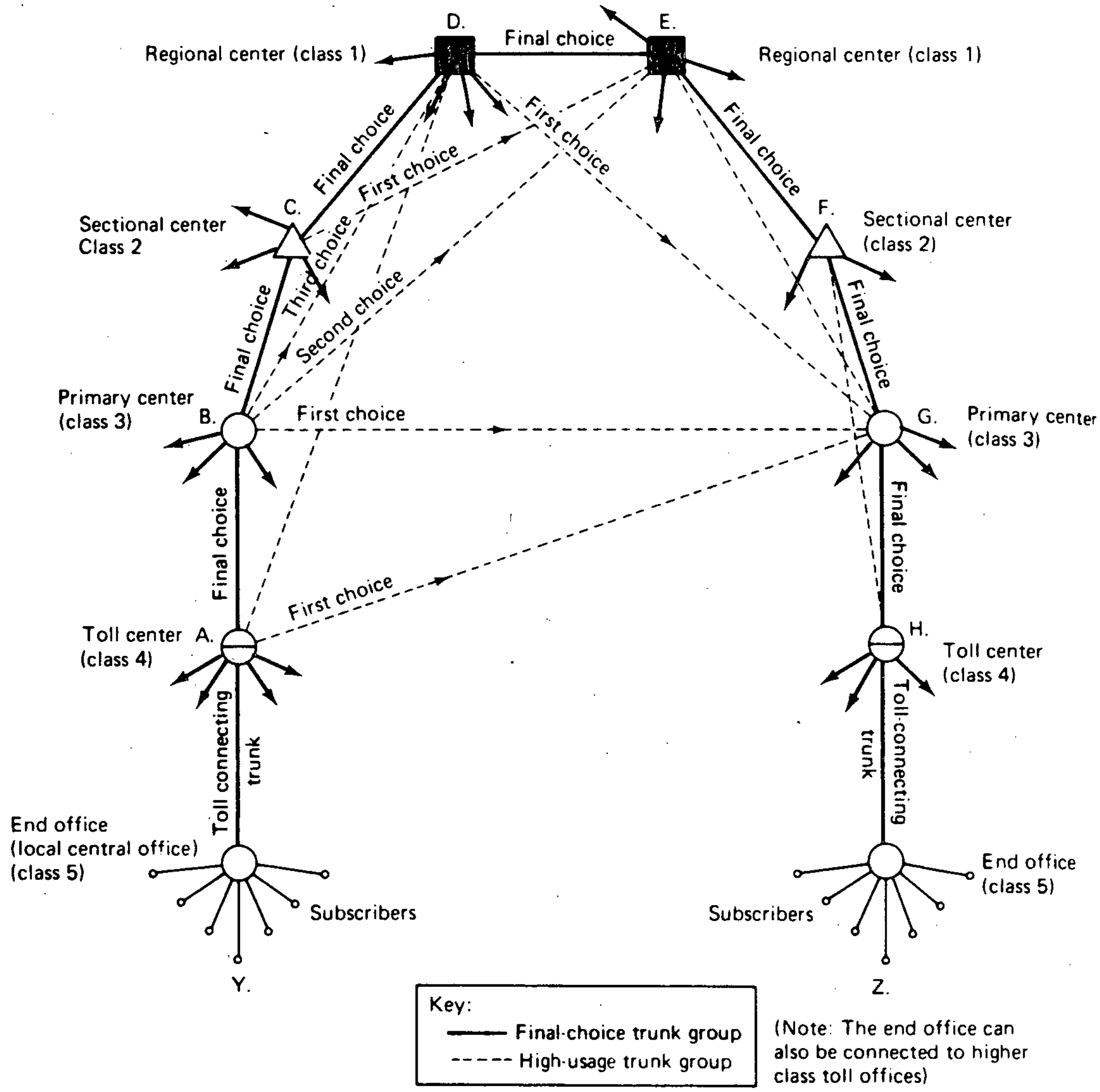

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Figure 2. (U) The Five Levels of Switching Office of the United States Showing the Choice of Paths When Subscriber Y Dials Subscriber Z

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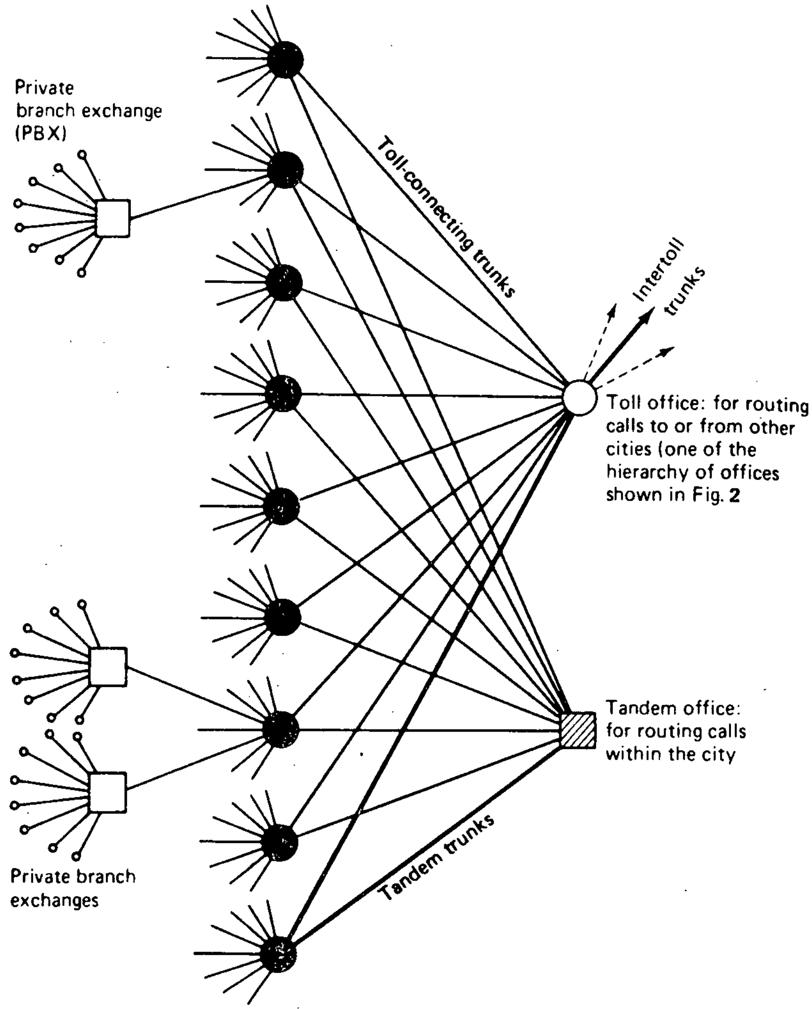

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Figure 3. (U) The Types of Telephone Exchanges Within a City

(U) All telephone switches or exchanges are comprised of a matrix, which establishes the actual connection between two parties, and the control unit which controls the matrix. (See Figure 4.) The matrix can be "electromechanical," such as a Strowger or crossbar, or an "electronic switch," such as a solid-state cross-point switch or a time division switch. The control used on the matrix can be predetermined by the way a switch is hardwired, or it can be controlled by an adaptable control unit that can allow the switch configuration to be changed to meet the needs of the users or the network.

(U) There are two general classes of exchanges--terminal and transit. (See Figure 4.) Terminal exchanges provide telephone lines directly to subscribers. The switching function will make connections through the switch either to other subscribers with lines on the same switch or to trunk lines connected to another exchange. Transit exchanges perform the same switching functions as the terminal exchange, except it provides connections only between other transit or terminal exchanges.

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(U) Private branch exchanges are special types of terminal exchanges that are dedicated to specific user groups. Any organization that requires a fairly large number of calls between its own users, as well as extensive outside calls, will usually benefit from installing its own PBX. This report is concerned only with some of the newer automatic versions of PBXs, PABXs. The level of PABX technology has improved so dramatically in the last few years that it is increasingly difficult to distinguish between local area end offices and PABXs on the basis of services and capacity. This fact has raised new concerns over the potential role of PABXs in military systems and will be addressed in more detail later in this study.

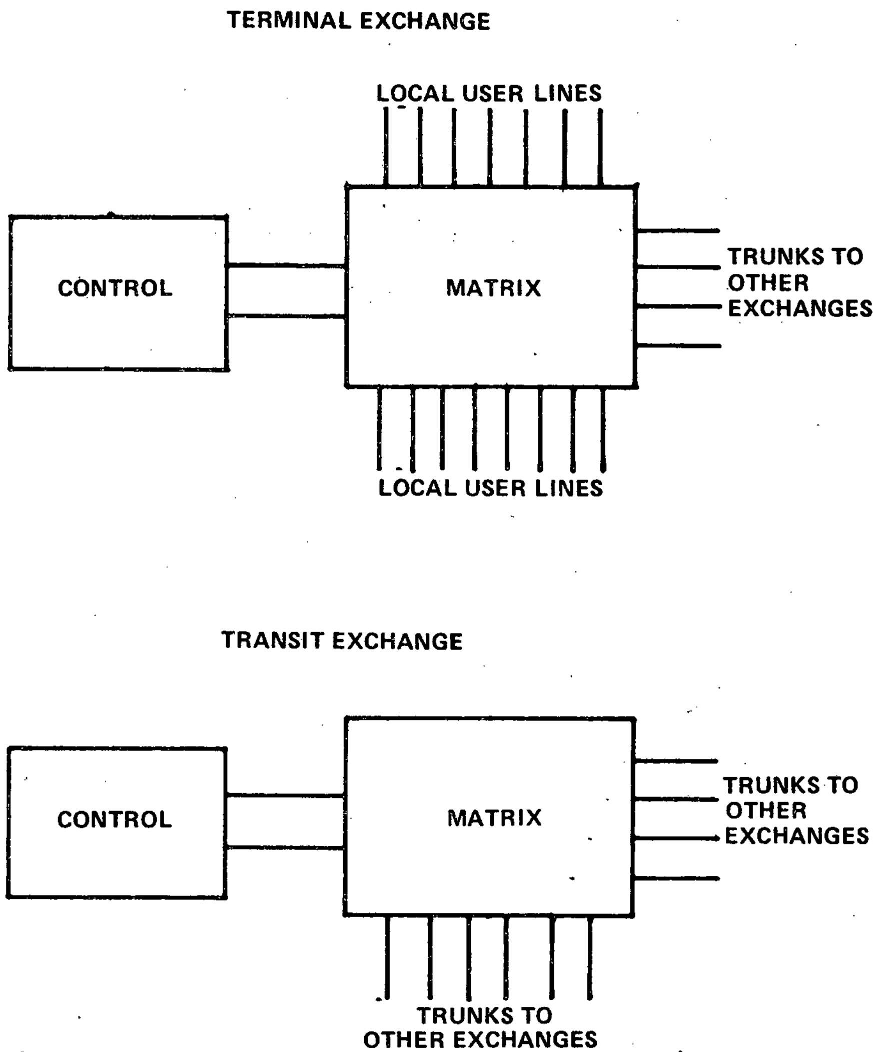

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Figure 4. (U) Classes of Telephone Switching Exchanges

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2.a. Control (U)

(U) Telephone switching has undergone tremendous changes in the last 10 years primarily as a result of microelectronic technology. Microelectronics has revolutionized telephone switching in two ways. First, it has allowed greatly improved speeds, reliability, and services of the switch matrix. Second, and more significant, microelectronics has allowed for the application of computers to the control portion of the switch. This latest development, called stored program control (SPC), can be used to very quickly and cheaply change the configuration of an individual switch.

(U) Stored program control is normally used for electronic or quasielectronic switching systems. This is accomplished by wired or software computer logic. SPC switches are space or time division switches that use customized computers as the control devices. The advantages of modern SPC switches are a significant reduction in equipment space, improved reliability, reduced costs for installation and maintenance, and a simpler and more economical means of obtaining compatibility with existing switching centers. SPC switches allow customized calling and maintenance features to be automated. The control computer can optimize call routing, and customers can get special calling features like abbreviated number dialing for frequently called numbers, automatic readdressing of calls to another telephone set, call waiting in case of a busy line, and conference communications involving three or more subscribers.

(U) The first digital, time division, SPC, central office circuit switching system which allowed digital trunk switching without demultiplexing was AT&T's ESS-4, introduced in 1976. Since that time, companies have made a number of improvements in the various systems available, and have greatly increased the power and functions of the computer control.

(U) Although predominantly time division switching systems are being produced, there are still many space division switches in operation. Almost all of the major switch manufacturers have ceased production of electromechanical space division systems. These systems are still being produced, however, by licensees in Communist nations and developing countries and represent an advance in technology for many WP countries.

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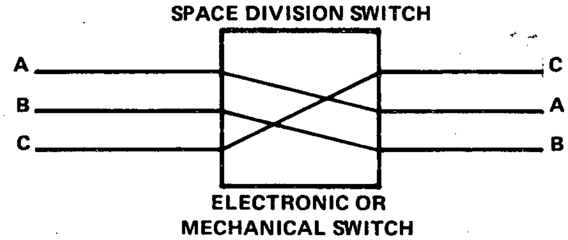

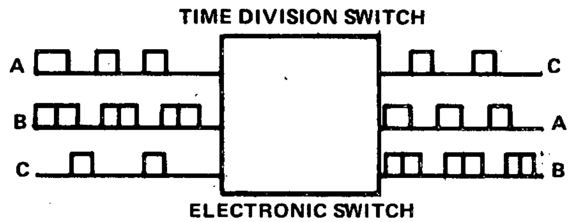

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Figure 5. (U) Space and Time Division Switches

2.b. Matrix (U)

(U) The function of the matrix is to make the actual connection between subscribers. This connection is part of either a logical or physical path. There are two main methods of switching, space and time division. Space division switching is an older method which uses electrical or mechanical contacts to switch inputs to different outputs. Time division switching is a newer switching method used to switch analog or digital signals. (See Figure 5.) A brief description of the common types of matrices are as follows:

-- (U) Strowger Switch:

(U) Also known as the step-by-step switch, this space division switch responds to a train of on/off pulses that are produced by a rotary dial telephone. One Strowger switch can connect an incoming wire to one of 10 outgoing wires. Although the Strowger switch was invented over 50 years ago, it is still the most common switch installed throughout the world. More than 25 percent of the telephone switching systems in the US use Strowger switches. Since a telephone exchange may be required to switch several thousand lines, which would require millions of crosspoints,

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multiple stages are combined to form one exchange. Using three or more stages reduces the probability of blocking; i.e., a probability of there not being a free path. Most modern exchanges use four stages.

-- (U) Crossbar Switch:

(U) A space division switch that connects the input wire to a number of possible output wires through a series of horizontal and vertical bars. The bars can be moved by electromagnets in such a way that they cause relay-like contacts to be closed at their coordinate intersection. Crossbar switches are faster and electrically quieter than Strowger switches.

-- (U) Quasielectronic Switch:

(U) A Soviet term for a stored program, space division switch in which the switching field is constructed with reed relays that have miniaturized components similar to the Bell System ESS-1.

-- (U) Electronic Switch:

(U) Replaces the electromechanical components of the switch with all electronic components. Electronic switches use space division or time division switching.

3. Technical Parameters (U)

(U) The major technical parameters considered for export control purposes relate to the system size and type. They are busy hour call attempts (BHCA), number of lines, number of trunks, and erlangs (another measure of traffic capacity).

(U) BHCA is a measure of the maximum number of call attempts that can be processed by the switch during the busiest hour of the day. Today, BHCA greater than 400,000 is common in large switches that are used at the highest levels in the switching hierarchy. (See Figure 2.) Switches used in local exchanges usually have BHCA of less than 150,000.

(U) The number of lines refers to the maximum number of permanent physical connections between users and a switch. The number of trunks refers to the maximum number of permanent connections between switches. The switch makes connections between lines and trunks as needed and then disconnects them when the call has been completed. Large switches have 50,000 or more lines and 20/25 K

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or more trunks.* Small-to-medium switches are generally considered to have 10,000 to 35/45 K lines and less than 20,000 trunks.

(U) The level of switch control basically refers to the sophistication of the stored program control (SPC) capabilities of the switch. The use of computers to provide SPC is the most important development in telecommunications technology of the last decade. The extensive use of SPC switches throughout a telecommunications system yields tremendous returns in efficiency, flexibility, survivability, and cost-effectiveness.

4. Military Utility (U)

(U) SPC switches can greatly improve the service capabilities, speed, and flexibility of communications networks for both voice and data transmission. The following features are of particular interest for military C^3 purposes:

(U) Adaptive routing -- SPC switching allows automatic rerouting of a call to another transmission path when the first-choice circuit is busy or not working.

(U) Common channel signaling -- SPC switching allows use of a dedicated control channel for all signaling functions (e.g., address information, status of connection) of a group of transmission channels, providing greater reliability and error control, more rapid connections, and improved network control and efficiency.

(U) Multi-level call preemption -- SPC switching allows priority servicing on a trunk-by-trunk basis, which is very important during military crisis situations.

(U) Reduced power requirements -- microelectronics allows switching functions to operate with less electric power.

(U) Remote line administration -- SPC switching features centralized operation and control centers for several exchanges, allowing remote number changes and automatic fault location and diagnosis.

(U) Size -- Modern SPC equipment is much more compact than earlier equipment due to advanced microelectronics.

(U) Speed -- direct interfacing and switching of digital data streams at 1.5 million bits-per-second (bps) and higher is possible.

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*(U) This report uses a consistent set of reasonable line and trunk capacities to differentiate between switch sizes because there are no standard sizes. This allows for the important distinction between switches which require marginal computing power and simple programs, and intelligent switches, which require significant computing power and sophisticated programs.

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(U) All of these features are important to the military user, for they improve the survivability of the communications network and increase the speed, reliability, and security of transmission.

(U) Terminal and transit exchanges each provide different capabilities to the potential military user. Recent technology trends in swithing are beginning to obscure some of the conventional exchange class distinctions, but equipment functional distinctions remain. The relative military utility of telephone exchanges is discussed, based on the technology, class, and size of the exchange.

(U) Terminal Exchanges. Terminal exchanges can be conveniently subdivided into dedicated and nondedicated systems. Dedicated terminals are usually PABXs that serve only a specific user group. In the terminal exchange category, PABXs have the highest potential military utility because they are typically more suited to military communications mobility requirements by virtue of size and weight. PABXs can be used on airborne command posts (ABNCP), on naval vessels and in mobile ground command posts. They can also be used in fixed military installations for dedicated users. As terminal exchange line size increases away from PABXs, direct military utility decreases. The military potential for terminal exchanges above 50,000 line size is low because it is undesirable to create high capacity nodes in a military network for survivability reasons.

(U) Transit Exchanges. Transit exchanges can be designed to interface with terminal exchanges and/or other transit exchanges. Transit exchanges that connect to other transits are the important nodes that help form the backbone of a high capacity switching network. These exchanges can also provide outlets into the national telecommunications network for dedicated military terminal exchanges. Further, in time of mobilization for war when national telecommunications systems become mainly a military asset, transits form the communications hubs vital to passing high volume traffic critical to military success.

(U) From a strategic point of view, PABXs and transits, as well as some small-to-medium line-sized terminal switches, potentially have high military utility. However, on a per-switch basis, a transit adds more to a strategic network capability than does a single PABX. A transit is also much more difficult to design and produce than a PABX. Thus, transit switches are most critical in terms of potential contribution to a national network and from the point of view of availability. Depending upon the installation sites and other variables, PABXs and other terminal class switches can have military utility as well. Finally, very large terminal switches are judged to have low potential for military utility.

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SECTION II

GOALS AND TRENDS IN WARSAW PACT COMMUNICATIONS SWITCHING (U)

1. Introduction (U)

(U) In these early years of the current "information age," it is becoming clear that any nation that does not develop a comprehensive, efficient, and dynamic telecommunications system will be at a disadvantage. That country will have difficulty maintaining scientific and economic parity with nations that do have these sophisticated information transfer systems. A modern telecommunications infrastructure is necessary to make the growing volumes of scientific and economic information available to using scientists, engineers, managers, and producers. Most Free World industrialized nations have fully embraced this fact, and during the last 20 years, great strides have been made in establishing major national and international information systems to handle both voice and digital information.

(U) Most Warsaw Pact (WP) countries have only recently come to terms with the scale of modern information systems needed to significantly impact a nation's scientific and economic strength. Free World telecommunications systems were developed for a dynamic and growing private market that demanded high-capacity, open information systems. On the other hand, WP telecommunications systems were developed by centralized bureaucracies to fill the customer needs that were prioritized according to narrow national goals and the need to control information flow. The various "Ministries of Communications" in East Bloc countries had to compete directly with other national programs and industries for funds and support.

(U) Since the late 1970's, the Soviet Union and other member countries for the Council for Mutual Economic Assistance (CEMA) have proposed major programs in the 11th and 12th Five-Year Plans to provide modern national information systems to their users. Many of their plans were directed at upgrading their basic telecommunications infrastructure such as the underground cable and microwave transmission systems and the intercity and local switching exchanges. The scale of this proposed upgrade is so large that the USSR and other CEMA countries simply cannot meet this demand without the transfer of Free World telecommunications technologies. They must import equipment, production capability, and expertise at all levels to complete the most basic requirements of the 11th and 12th Five-Year Plans.

(S) Much of the requirements of the 11th and 12th Five-Year Plans are stated in terms of civil telecommunications technologies, but as stated previously, certain switching systems have significant potential for use in military systems. It is significant to note that the two types of switches most needed to fulfill Soviet stated goals, small-to-medium transit switches and PABXs, are the two types of switches that have the greatest military potential.

(U) In February 1985, the Council of Ministers of the USSR and the Central Committee of the Soviet Communist Party jointly decided on a massive program concerning the development of the country's telephone network during the 12th

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Five-Year Plan (1986-1990). According to their joint decree, 10 million new subscriber numbers are to be added to the existing network in the cities, of which 75 percent will go to private households; every school, medical establishment, commercial enterprise, and cultural institution in the country will have a phone.

(U) Their decree also stated that the number of subscriber sets linked to the intercity trunk network must be trebled during the 12th Five-Year Plan, increased sevenfold by the year 2000, and the number of public phone booths must be increased considerably. Furthermore, larger organizations which use over 50 telephone sets were told they will have to buy an in-house Private Automatic Branch Exchange (PABX), and telephone equipment manufacturing enterprises were instructed to comply with the hierarchy's edict and create the technical equipment required for the envisaged full-scale development of the country's telephone network.

(S) To complete this ambitious expansion program, the Soviets must upgrade both their transmission system and switching infrastructures. Although their transmission systems are deteriorating, the Soviets do have a limited capability to meet their near-term expansion requirements through conventional microwave and metallic cable. Switching systems, however, present a different problem for Soviet planners. This problem arises because of the Soviets' inability to produce microelectronic components for the SPC switches needed to support their infrastructure upgrade. While technology transfer is important to the upgrade of both transmission and switching systems, it is crucial in the latter.

2. UACS and VAKSS Programs (U)

(U) Since 1965, the Soviets have given a high priority in their Five-Year Plans toward developing a nationwide Unified Automated Communication System (UACS), which they refer to as YeASS. The UACS program is intended to provide nationwide reliable transmission of telephone, telegraph, facsimile, and data communications. Soviet efforts are directed toward the expansion and complete conversion of their current telecommunications network to provide completely automated switching. New generations of analog and digital, multichannel transmission systems are being introduced to fulfill the UACS transmission system requirements.

(U) To fulfill the UACS plan, the Soviets are introducing digital switching exchanges and transmission systems. Transition to a digital transmission system will be slow because of the scale of the analog telecommunications infrastructure already in place.

(C) The Warsaw Pact (WP) countries had been striving to introduce stored program controlled (SPC) switches in some key zonal nodes of their network during the 11th Five-Year Plan (1981-1985). These SPC switches were installed in a number of key long distance exchanges and some national automated switching control centers. Six high-capacity, national-level automated switching control centers (UAKs) were installed as part of this program. Several first-generation SPC quasielectronic and fully electronic switching systems were placed in long

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distance service by the end of 1985. In addition, the Soviets are planning to introduce the quasielectronic ISTOK in local switching networks.

(C) In conjunction with these switching developments, the 11th Five-Year Plan has resulted in the deployment of some IKM-30 (30-channel) time division multiplexed (TDM) transmission systems on key links. A few IKM-120 (120-channel) TDM and VOLS-120 (120-channel) optical transmission systems have also been introduced into key intrazone telephone network trunks. The IKM-480 (480-channel) TDM transmission system, designed for regional trunk networks, was expected to be operational prior to 1985. The IKM-1920 (1920-channel) TDM transmission system is expected to be available post-1985 for initial deployment in interzone trunk networks.

(C) Analysis of the WP country goals for the period 1985-1990 indicates that they will install more electronic switching exchanges, and more sophisticated network control using computers. This effort will include centralized computer network control of quasielectronic and electronic exchanges.

(S) A program similar to UACS, referred to as Vzaimosvyazannoy Avtomatizirovannoy Kompleksnoy Sistemi Svyazi (VAKSS), has been underway since 1972 to develop a unified communications system to interlink the WP countries, as well as Cuba, Vietnam, and Mongolia. These countries are in the Council for Mutual Economic Assistance (CEMA). The VAKSS program is designed to provide international automated transmission of telephone, telegraph, facsimile, video, and data communications, thereby increasing the total information transfer capability of the WP and improving their command, control, and communications capabilities. This system is controlled by Moscow.

(S) SPC controlled switching, which will have dramatic impact on their information transfer capability, was programmed to be phased into the networks in the 1981-1985 period, and full scale automation and centralized control of the entire network is to be installed in the 1986-1990 period. The Soviet Union is the primary architect of the VAKSS program. The backbone network was completed in 1985. The current Five-Year Plan calls for providing operators with diagnostic and monitoring equipment. The introduction of an embedded diagnostic capability is scheduled for introduction in the 1991-1995 period.

3. IDN and ISDN (U)

(U) Analysis of the UACS and VAKSS programs indicates that the WP and associated CEMA countries are striving to achieve an integrated digital network (IDN). The key elements required to achieve an IDN are SPC switching and digital transmission equipment. These elements are being developed under the UACS and VAKSS programs.

(U) The IDN is the first step in achieving an integrated services digital network (ISDN). The IDN provides subscribers with a standard digital interface over which they may transmit and receive digital telephony and other forms of digital information. The ISDN will provide the subscriber with all of the services of the IDN, which includes end-to-end digital subscriber services, plus specialized services.

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(U) The main difference between the IDN and ISDN is the bandwidth of the customer data channel. The ISDN will allow wideband services, such as videotext and facsimile, to be added to the services provided by the IDN. The ISDN phase of the evolution will require the replacement of electromechanical and mechanical switches with electronic digital switches and an increased use of wideband transmission systems within the zonal and interzonal networks. These systems are being installed to achieve greater transmission bandwidths.

(C) Currently, the WP countries' goal is a limited, but significant, IDN capability in telephony (about 15 percent of main lines connected to digital exchanges, circa 1995). The next phase in their telecommunication evolution will be to initiate the integration of voice and non-voice services, including selected wideband services.

(C) The pacing factors which impact the WP countries' achievement of an IDN capability are the cost-effectiveness and availability of digital equipment. The capital investments in existing analog networks are enormous; therefore, the introduction of the newer equipment required for an IDN must be economically justified. Soviet literature on telecommunications abounds with discussions on economics and reliability as the ruling factors in the replacement of old equipment.

(C) As early as the 1971-1975 period, the Soviets, in concert with the CEMA countries involved in the VAKSS program, identified SPC switching as the main element in achieving an IDN and agreed to acquire such switches via procurement, license, and domestic development. Domestic development has concentrated on the quasielectronic switch which the Soviets have classified as an intermediate system. This decision obviously was a "fail-safe" course of action in view of their domestic deficiencies in electronic switching production technology, particularly in the area of microelectronics. These quasielectronic switches also offer considerable hardness to electromagnetic pulse (EMP), thus improving survivability.

(C) Acquisition of new reliable equipment from the Free World is a way for the necessary switching and transmission equipment to be acquired. Because of the deficiencies in their indigenous production capability, the Soviets are capitalizing on acquisition via technology transfer of SPC switching and digital transmission equipment.

(U) Research on communication architecture related to an IDN has been underway since the early 1960's. This early effort culminated in the development of technical specifications for an IDN circa 1975. The State Standards Committee of the USSR Council of Ministers adopted the standards for terminology and the general concept for the IDN on 25 August 1975 (GOST-22670-77). They decreed that these standards become law on 1 January 1979. This document essentially translates all the CCITT standards on terminology relating to the IDN into the Russian language.

(U) The requirement for an ISDN was validated in 1982 by the Moscow Executive Committee of the Main Scientific Research Center which plan Moscow's

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control systems. This committee concluded that communication networks should be unified for transmitting all forms of information required to manage cities. Subscribers should be provided with a single line for telephone, telegraph, and facsimile communications, as well as data and video text signals (i.e., ISDN). This committee also concluded that these requirements can only be satisfied by an IDN with automatic electronic switching exchanges.

(C) The evolution of WP countries to an ISDN will continue to be organized by the Soviets. The transition from existing networks to a limited ISDN capability will depend on availability of foreign technology, indigenous Soviet capability, and could require as much as 20 to 30 years. Technology transfer has been, and will continue to be, a significant avenue for acquiring the equipment and technology needed for the Soviet IDN and ultimately an ISDN.

(S) The extent to which WP countries are successful in advancing toward their IDN and ISDN goals will affect the degree to which they can upgrade the effectiveness of their military command and control system. This technology can lead to vast improvements (at echelon levels from General Staff to Regiment) in their automated systems for indications and warning, force management, and weapons control. The IDN architecture provides distributed network control functions, adaptive routing, and permits selective hardening of key nodes which considerably enhances the survivability of their communications.

(U) Soviet plans for fiber optic transmission systems called for the resolution of fundamental problems in the development of equipment and cables during the 11th Five-Year Plan in order to introduce this equipment into networks on a wide scale in the late 1980's.

(C) Analysis of the plans and trends described above indicates that the WP countries are following a migration strategy leading to an IDN by

- (C) Completing the modernization and automation of the existing local analog switching networks by replacing all manual exchanges with modern crossbar and quasielectronic exchanges.

- (C) Continuing the installation of decadic converters (see Figure 7) to automate the interface of the older 10-step exchanges with the newer automated crossbar exchanges. Thus, those 10-step exchanges installed in the 1960's can continue in service for their remaining useful life.

- (C) Completing the system of zonal networks by installing modern crossbar and SPC quasielectronic exchanges. Beginning installation of digital (PCM) trunk networks between long distance exchanges at the zone level. (See Figure 6.)

- (C) Unifying the established 10-step/crossbar trunk network into a common analog trunk network by using SPC quasielectronic and SPC crossbar switching systems.

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- (C) Beginning establishment of new dedicated telephone, telegraph, data, facsimile, etc. end-to-end integrated digital networks (IDN) at the zone level and interfacing with the existing network using converters (transmultiplexers) at critical switching nodes.

- (C) Beginning construction of centrally-controlled, high-capacity, digital switching and transmission systems at the higher levels in the national primary network forming a backbone digital network. Interfacing these digital systems at critical transit nodes with the common trunk crossbar and quasielectronic analog network.

- (C) Replacing analog systems as the need to upgrade them arises until all dedicated networks are digital throughout.

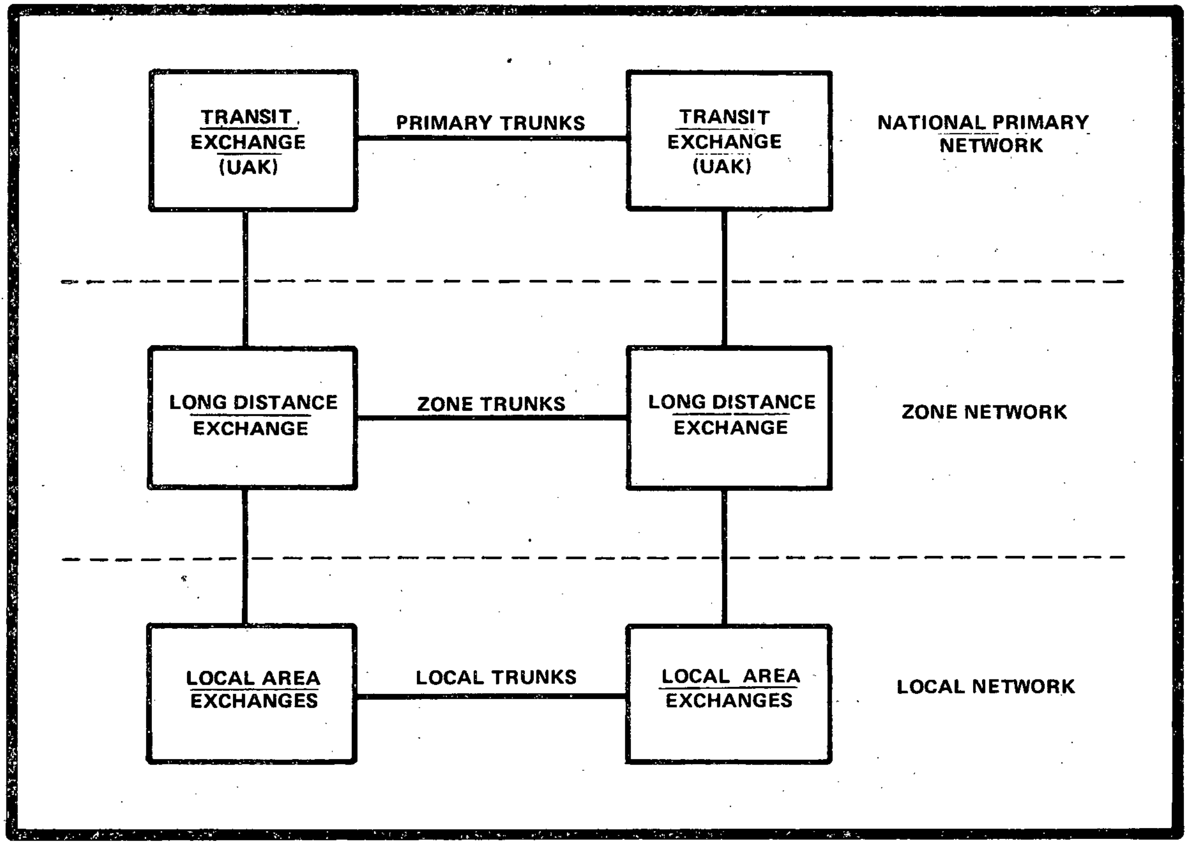

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Figure 6. (U) Hierarchical Network Structure in the USSR

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SECTION III

CURRENT WARSAW PACT SWITCHING TECHNOLOGY (U)

1. Evolution of the State of Switching (U)

(U) Contemporary switching within the Warsaw Pact (WP) countries can best be understood by reviewing the evolution of switching within these countries. The pattern of development has varied widely for each country and has been driven by a combination of military requirements, the economic capability of the country, and to a lesser degree, by the needs of the public. By comparison, the development of US telecommunication systems was driven primarily by the market place. Special military and economic considerations were made when absolutely necessary.

(U) Development of network switching in the Soviet Union has followed a disorganzied course where each district (oblast) was allowed to develop its own public communications network, and each organization was allowed to build its own private network. In the 1920's switching within the USSR was manual, and long distance calls were made by simply patching from oblast to oblast. Interconnectivity that would allow every oblast or organization to communicate with every other oblast or organization would require a "fully meshed" network. For a country the size of the Soviet Union, this interconnection would be prohibitively expensive and was not done. Only the more important traffic routes were interconnected, resulting in adjacent oblasts or organizations with no direct circuits. Effecting connections in such a network required a great deal of ingenuity on the part of the operators, and the solution to the problem was never properly addressed until the UACS was mandated by the 24th Soviet Communist Party Congress.

(U) The task of unifying the vast Soviet network, as required by UACS, was to first develop a feasible approach that would eventually establish fully automated switching. The oblast system that had evolved up to that point was predominantly manual with a small percentage (approximately 15 percent) of the long distance exchanges employing semiautomatic operation. A summary of the steps in the evolution leading up to the UACS is presented below:

- (U) Manual switchboards, types TSB and MB, were developed and deployed beginning in the late 1920's. The Soviets continue to use some of these manual systems in rural areas and plan to replace the last of them in 1988.

- (U) Semiautomatic (operator serviced) inter-oblast and long distance exchanges using Strowger (10-step) selectors and two-frequency line signaling were introduced from the 1930's into the 1960's.

- (U) Semiautomatic transit exchanges, type MRU, using 10-step selectors and single-frequency, operator-key, pulsed signaling were deployed beginning in the 1950's, and many are probably still in service.

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- (U) Fully automatic long distance, 10-step switching system deployment was initiated in the inter-oblast network around the mid-1960's with the domestically produced AMTS-1M.

- (U) Fully automatic long distance crossbar switching system deployment was initiated in the national network in the early 1970's with the ARM-20 crossbar transit exchange imported from Sweden and Yugoslavia. Deployment of the domestically produced AMTS-2 and AMTS-3 crossbar exchanges was also initiated in the inter-oblast networks and the newly created networks during this period.

- (U) A dual, long distance trunk system was established in the early 1970's by interfacing crossbar and 10-step switches at high capacity junctions. This system allows automatic completion of calls initiated by either the crossbar or 10-step equipment.

(U) The dual trunk system now in operation in the USSR (Figure 7) only minimally accomplishes the task of automating long distance connections. It is inefficient and unreliable for military use. The current Soviet drive is designed to consolidate the structure, through an evolutionary equipment interface/replacement process, into one trunk system with common channel signaling (Figure 8).

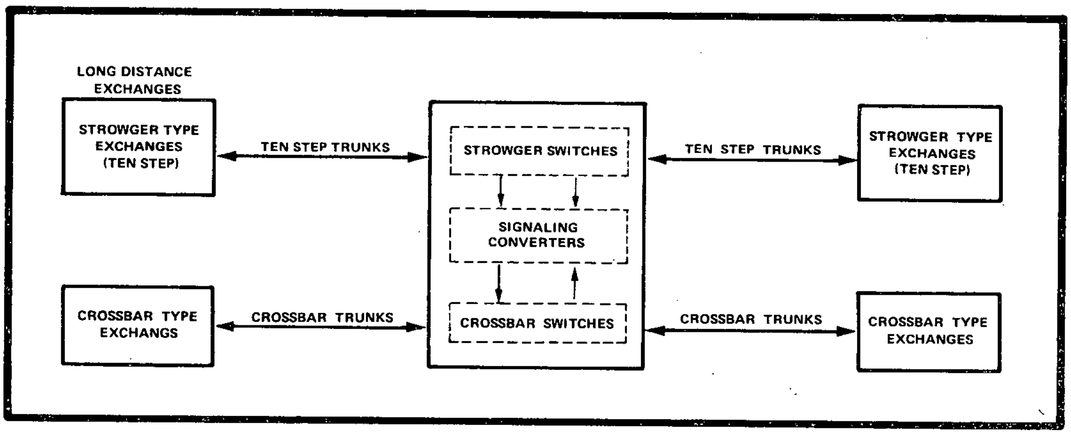

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Figure 7. (U) Dual Long Distance Telephone Trunking System for Interconnections of the UACS in the USSR

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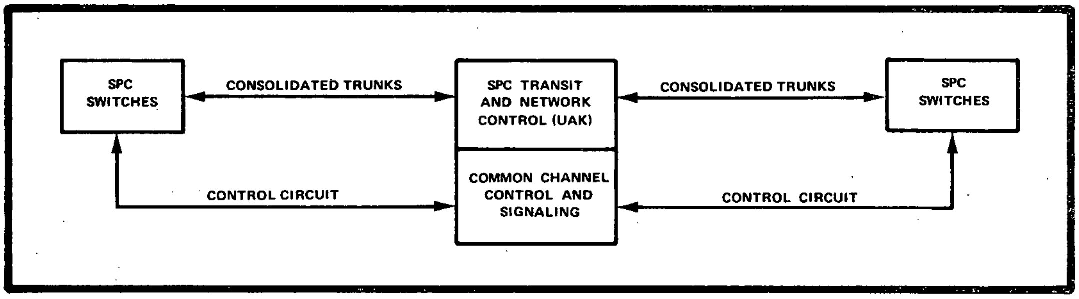

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Figure 8. (U) Consolidated Long Distance Telephone Trunking System for Future Interconnection of the UACS and/or the IDN of the USSR

(U) In Poland, the first manual exchanges produced were placed in service in 1946. The first 10-step automatic exchanges were in operation in 1948 and then modernized in 1956. The first crossbar exchanges were imported in the 1950's. Poland has produced E-10A exchanges under license from CIT-Alcatel* of France since 1976. The E-10A is a wired-logic, time division, central office that uses a digital computer for management functions only. In July 1981, Poland was producing E-10's at the approximate rate of 100,000 lines per year.

(FOUO) Czechoslovakia, Hungary, Romania, and Bulgaria have developed their networks almost exclusively with imported switching systems. According to a January 1984 report by the Bulgarian Communications Industry Institute (CII), it has a number of telephone exchange products under development. These products range from space division analog systems to an electronic exchange with a 480- to 8000-line capacity using Soviet know-how.

(U) Beloiannisz Telecommunication Engineering Plant (BHG), in Hungary, reported in 1983 that it was developing a computer control system to upgrade its ARMs to SPC systems. Budavox of Hungary markets the ARM-20 system outside of Hungary. The ARM-20 system is an electromechanical register and marker controlled system (not SPC) with crossbar switches, under license from Ericsson. In 1984, Ericsson reported that Hungary had 43 ARM transit exchanges in operation with a total capacity of 37,960 trunks, presumably manufactured by BHG.

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*Now part of the French firm Alcatel, which is composed of CIT-Alcatel and Thompson CSF.

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(U) East Germany inherited the most advanced 10-step system from prewar development. They developed and produced their own crossbar equipment beginning in the early 1960's. In addition to the GDR cooperative with the USSR to develop the quasielectronic ENSAD, the GDR is developing a small (rural) digital, time division, 96-line exchange designated the OZ-100D. A prototype was exhibited by its manufacturer, the Communications Electronics Combine VEB, in July 1983 at the Leipzig Trade Fair. The computer control contains a "U 880" 8-bit microprocessor.

(U) The Soviet Union and most East Bloc countries have focused on research into SPC electronic switching and integrated communication network architecture related to an IDN beginning in the early 1960's. This research was aimed at determining the main requirements for digital transmission systems, the development of models for individual types of equipment, and the development of technical specifications for an IDN. Circa 1975 this research effort formulated IDN standards for switching centers, algorithms for implementing program control of services, interaction between electronic and existing switching exchanges, and the interaction of electronic exchanges and junctions within an integrated network. This effort indicated that progress in the development of an IDN would be limited by the evolution in indigenous production technology for SPC switching systems.

(U) In 1978, the VAKSS CEMA members agreed on the following in regard to switching:

- (U) To continue the development of integrated digital communication systems in order to achieve a future capability for digital switching and transmission technology. The technical requirements for urban electronic exchanges with standardized digital transmission and switching techniques, as well as program control, were also included in this agreement.

- (U) To explore the means of introducing electronic telephone exchanges in older regions of larger cities without requiring extensive reconstruction of the existing networks.

- (U) To approve the technical requirements for the introduction of quasielectronic automatic long distance telephone exchanges, including centralized program control, to permit modernization of the telephone networks for member countries.

(C-NF) In the late 1970's and into the early 1980's, the emphasis on telephone switching equipment was on increased electronic exchanges which were being developed with imported technology from the Free World. The USSR had acquired not only a quasielectronic Metaconta 10C but also fully electronic MT-20 and MT-25 time division switching technology.

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2. Indigenous Technology (U)

(U) This section examines switching technology indigenous to the WP countries. The following paragraphs describe the Kvarts (a quasielectronic exchange), a substation (remote switching unit) version of Kvarts, the MKRB (a radio telephone switching system), the EP-128 (a private branch exchange), and the LOTRIMOS (an automatic monitoring-diagnostic system). The technology represented by this equipment, when introduced into the networks of the WP countries, can lead to significant improvements in their indication and warning, force management, and weapons C^3 systems.

(C) The Soviets have at least two central office switching systems in production, the KVARTS and the ISTOK. Both are space division analog switches. The ISTOK is a joint undertaking between the Soviets and the GDR; the GDR version is called ENSAD. Field trials were completed in 1980, and prototype production of smaller versions (256, 1925, and 4096 lines) began in 1983-1984 in the GDR. A March 1984 report stated that the introduction of the ISTOK exchanges on local telephone networks had begun. The ISTOK switches individual analog and PCM digital voice channels through a common reed relay matrix, allowing it to interface with both analog and digital communications circuits with analog-to-digital and digital-to-analog converters.

(U) The network enhancements which will result from installation of these systems are listed below:

- (U) Quasielectronic exchanges may operate autonomously or from centralized control. SPC provides extended services which include rapid setting up of conference calls and preemptory interruption for priority calls. Alternative stations can assume control when the primary control station is lost without disrupting the network.

- (U) Substations operate under control of a main exchange. They provide many of the services of the main exchange in a small space with low power consumption. Substations provide concentration of lines to the main exchange for more efficient circuit utilization.

- (U) Radiotelephones provide switching similar to a subexchange. They extend the fixed telephone network for access by mobile military units.

- (U) PBXs may operate in conjunction with a main exchange but provide their own control. They can provide a fairly large military complex with independent internal communication as well as access to an outside national network. They can also be used to build private networks such as the US military AUTOVON system.

- (U) Automatic monitor-diagnostic systems monitor and automatically diagnose network circuit and switching problems. They can provide immediate routing around problem areas so that traffic critical to military C^3 operations can be maintained.

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2.a. KVARTS - Long Distance Telephone Exchange (U)

(C) The KVARTS is an SPC reed relay exchange used for terminal and transit use, with a maximum capacity of 40,000 to 50,000 numbers. The first prototype model was installed in the Soviet Union in 1983, and according to a March 1984 report, series production was to begin in 1985. The USSR plans to introduce KVARTS into their long distance network during the 1986-1990 Five-Year Plan. Czechoslovakia also planned to begin production of the KVARTS in 1985.

(U) The KVARTS exchanges are of modular design. Each module contains the equipment for a switching field having 1024 x 2 inputs/outputs, the equipment for connecting trunks and long distance lines, and the peripheral control devices. The switching fields employ reed switches or ferreed crosspoints, which are controlled by integrated circuits. KVARTS exchanges employ a central stored program control complex designated as the Neva-1M.

(U) The Neva-1M stored program control consists of two special-purpose Neva-1 computers which operate in a parallel, non-load sharing, synchronous mode. Each Neva-1 includes five functional units: the main and peripheral processors, a memory interface, a channel unit, and a control console. A typical feature of this computer is its ability to work with both a fixed and an arbitrary quanta of information, ranging from 1 to 32 bits. This ability reduces the processing time for the majority of programs and offers a substantial memory savings.

(U) The speed of the Neva-1 computer is 750,000 operations per second. It has a memory of 8 megabits and is capable of processing up to 45 calls per second. The Neva-1 can service a KVARTS telephone exchange. KVARTS exchange equipment is being produced by the Riga Production Association of the USSR, and the associated Neva-1M is being produced by Robotron of East Germany.

2.b. KVARTS - Telephone Substation (U)

(U) There is a version of the KVARTS which is a quasielectronic telephone substation. This switching system is designed to concentrate the telephone traffic of subscribers which are connected via a telephone substation to a main exchange. The substation is connected via trunks to a key quasielectronic city exchange and is controlled by that exchange. The substation can be installed within the facility housing the quasielectronic city exchange or at another facility which may be located at a substantial distance from the controlling exchange. In remote applications, the control signals from the primary exchange are transmitted to the substation via a common control trunk.

(U) The KVARTS telephone substation can serve up to 2048 subscribers via 512 trunks with a controlling exchange, thus providing a concentration of 4 to 1. This substation is probably also produced by the Riga Production Association VEB of the USSR.

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2.c. MRKB Automatic Radiotelephone System (U)

(U) The MKRB radiotelephone system is designed to facilitate an interface with the telephone network for communications between mobile and fixed subscribers. The system is comprised of an automatic exchange, radio base station, mobile stations, and control units. It uses 2, 4, 6, or 8 duplex radio channels to communicate with up to 500 mobile subscribers with 8 RF channels. Options for radio transmission involve bands centered on 80, 160, or 450 MHz.

(U) The distance between the radio base station and its subscribers is limited by line-of-sight transmission due to the radio frequencies used. The system has a diversity reception capability, and can be configured for mobile networks. The automatic exchange can have up to 15 trunks with the civil telephone exchange and up to 20 dispatcher lines. The MRKB system is similar to the Soviet ALTAY-3M radiotelephone which is operational in the Moscow area. The MRKB radiotelephone is produced by the BRG Radio Engineering Factory of Hungary.

2.d. EP-128 Private Branch Exchange (PBX) (U)

(U) The EP-128 is an automatic SPC electronic PBX. The system, manufactured by the BHG Telecommunications Works of Hungary, is comprised of a control unit (MAT 512/2), periphery units, and an electronic switching unit. Model A of the EP-128 can service within a localized organization. Models A and D can have up to 28 and 112 trunks, respectively, with the main exchange.

(U) The EP-128 equipment is of modular design, employing integrated circuits. The SPC subsystem is designed to provide subscribers a wide variety of services. The SPC capability also gives the system a diagnostic capability. The EP-128 operates on a 48V DC power supply.

2.e. LOTRIMOS Monitoring and Diagnostic System (U)

(U) An example of WP efforts to develop automated centralized monitoring and diagnostic equipment for telephone networks is represented by the LOTRIMOS system. This system is referred to as a service supervision and maintenance system by the manufacturer, the BHG Telecommunications Works of Hungary. The LOTRIMOS is designed to operate on national as well as on local level networks. It collects, classifies, and displays statistics on critical operational network parameters as well as performing network analysis. This information is used in network planning, control, and maintenance operations. The LOTRIMOS is similar to the ASOTO equipment which is undergoing tests within the USSR.

(U) The LOTRIMOS is comprised of a central computer center which serves the various administrative centers. (See Figure 9.) The central processing unit (CPU) is connected to distributed intelligent subsystem terminals referred to as TIMOS and LIMOS. The TIMOS terminals are designed to monitor transit exchanges and the LIMOS terminals are designed to monitor subscriber telephone exchanges.

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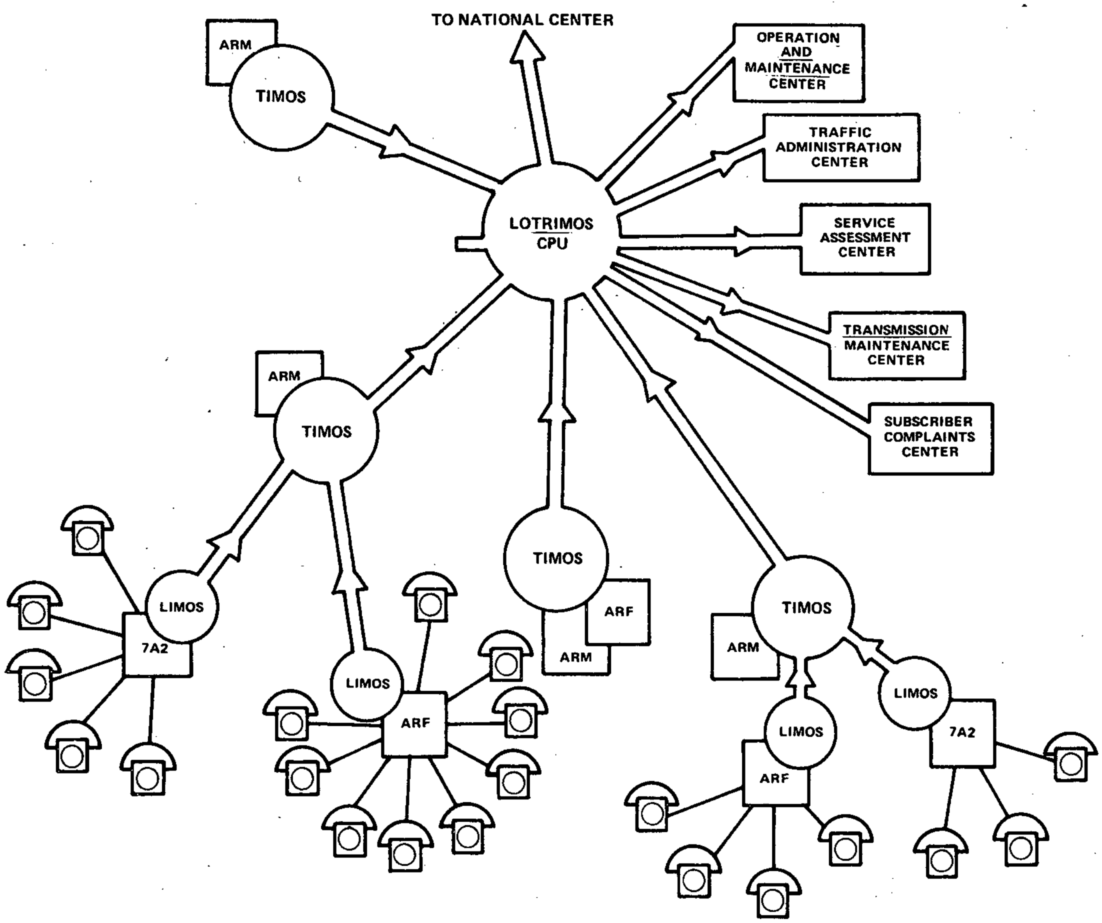

LEGEND:

CPU – CENTRAL PROCESSING UNIT
TIMOS – TRANSIT EXCHANGE INTEGRATED MEASURING AND OBSERVATION SYSTEM
LIMOS – LOCAL EXCHANGE INTEGRATED MEASURING AND OBSERVATION SYSTEM
ARM – TRANSIT CROSSBAR EXCHANGE
ARF – LOCAL CROSSBAR EXCHANGE
7A2 – ROTARY EXCHANGE

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Figure 9. (U) LOTRIMOS Regional Configuration

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(U) The central computer for LOTRIMOS is a TPA-11 which is manufactured in Hungary. This computer has a 16-bit word length, and it has an architecture compatible with the US manufactured PDP-11 computer. Asynchronous frequency-shift-keying (FSK) modems having a 1200 bits per second (bps) capability are normally used for data transmission between intelligent terminal, the CPU, and the national center. (A data transmission capability of 9600 bps is possible between the CPU and the national center.)

3. Summary (U)

(C) Eastern Europe and the Soviet Union are well behind the West in their development of digital, time division, SPC switching. An analog, space division, SPC exchange with small line capacity (the 16,000 line KVARTS) is just entering production. The digital, time division, central office systems under development have very small line capacities. The systems being developed in the East Bloc do not employ distributed microprocessors to the extent used in the West.

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SECTION IV

TECHNOLOGY TRANSFER (U)

1. Deficiencies (U)

(C) Soviet stated requirements for switching systems minus their indigenous production capability yields a well defined set of deficiencies that must be filled to meet their goals. The Soviets must come up with large numbers of switches of all sizes. To provide an efficient national network, they must import SPC transit switches that they are not able to produce themselves. To provide local access to that national network, they must improve their production capability of medium and smaller terminal switches. In all likelihood, they will also have to import large numbers of these switches from the Free World to make up for their low production rate. Finally, they must produce and import large numbers of PABXs to improve the efficiency of state enterprises or agencies and keep their increasing demands for line connections from overloading their local exchanges.

(S-NF) Indications are that current embargoes on SPC switching has had an adverse impact on the upgrade of the Soviet telecommunications system. While the Soviets do have access to numbers of switches and modern transmission systems, it is clear that they are not able to import the necessary quantities because of the restrictions placed on these technologies by the Coordinating Committee (COCOM). Even with unrestricted access to Free World technology, the Soviets have a formidable task ahead of them. With the current COCOM restrictions on SPC switching, the realization of their goals seems even more remote. If the restrictions were expanded slightly to include PABXs and small-to-medium SPC transit switches, the Soviets would face a long delay in their entry into the information age, and their military command and control capabilities would suffer considerably.

2. Past Technology Transfer (U)

(U) It is apparent that in the 1971-1975 period the Soviets, in concert with the CEMA countries involved in the VAKSS program, agreed to pursue at least three courses of action in the acquisition of SPC electronic switches in order to improve their switching capabilities. The three courses of action were

- (U) to develop a domestic capability for producing SPC electronic switches based upon the acquisition of foreign licenses;

- (U) to procure foreign SPC electronic and quasielectronic switches; and

- (U) to develop a domestic capability for producing quasielectronic switches.

The developments resulting from these three courses of action are presented in the following paragraphs.

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2.a. Domestic Production of SPC Switches Based on Foreign License (U)

(U) Poland purchased the E-10 non-electronic switch in 1976. This switch was later modified to include a computer and is currently being produced at an unknown rate in Poland under license from CIT-Alcatel* of France. The E-10 exchange is comprised of modules which permit the system to be adapted to international, transit, trunk, local, and private exchange applications. The basic module of this system can be configured to have a capacity of up to 1500 subscriber lines, 1800 trunk circuits, or a mixed proportion of lines and trunk circuits. The E-10 also provides centralized computer supervision of maintenance.

(U) The E-10 has been installed in Poznan, Gdansk, and the international exchange in Warsaw, Poland. An E-10 was operational in the Czechoslovakian network in 1981, and two additional exchanges were ordered in December 1983. Also in 1983, the Soviets ordered an E-10 exchange which was scheduled for delivery in 1986 at Kiev.

(U) A significant contract was accomplished in 1979 to provide the Soviets more advanced switching technology than the E-10 exchange. This technology is represented by the MT-20 series of time division, SPC switches developed by Thomson-CSF of France. The MT-20 and MT-25 time division switches were planned to be introduced in Leningrad exchanges during the 1982-1983 period.

(U) The USSR also contracted with Thomson-CSF to construct a manufacturing plant at Ufa, USSR for the production of MT-20 time division exchanges. This plant was planned to have a capacity of producing exchanges for more than one million 0.17 Erlang-lines per year. This production facility was supposed to achieve an initial operational capability by the end of 1984. The employment of these exchanges will permit the Soviets to cost-effectively integrate their transmission and switching systems into their evolving digital networks.

(S-NF) In 1983, Thomson-CSF, the manufacturer and vendor of the MT-20, took steps to insure that MT-20 systems destined for the USSR contained older, less sophisticated, integrated circuit microprocessor technology than used in current off-the-shelf models. The advanced microprocessors are produced by Thomson-CSF under US license and incorporate technology restricted by COCOM. The Soviets objected to the MT-20 systems with older, less capable microprocessor technology and apparently attempted to circumvent the impact of this agreement.

2.b. Imported SPC Electronic and Quasielectronic Switches (U)

(S) COCOM controls on SPC switches have been effective since at least 1983. This fact is evidenced by the limited number of electronic SPC switches being

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legally imported by the WP. Additionally, several bids for these switches have recently been withdrawn by the manufacturers, leaving major gaps in the WP's infrastructure upgrade.

(U) Finland and Yugoslavia have been sources of electronic switching. Both of these countries are involved in the CEMA agreements. Telenokia of Finland, a subsidiary of the computer firm Nokia, produced the DX-100 and DX-200 SPC electronic exchanges. The DX-100 is an electronic SPC switch which was produced using technology under license from CIT-Alcatel* of France and now appears to have been dropped. The DX-200 series is an indigenous Finnish development which can service from several hundred up to 40,000 subscribers. The first DX-200 exchange was reported to have been installed in Leningrad in early 1984. The subscriber capacity of this exchange is unknown.

(U) The L. M. Ericsson Company of Finland produces the AXE series of SPC electronic switches and has contracted with the Soviet Union for delivery of an AXE exchange. This exchange was programmed to be installed in the city of Zaparozhe, Ukraine, by December 1983, but the sale was not made. The Nikola Tesla Company of Yugoslavia also produces the AXE-10 exchange under license from L. M. Ericsson Company of Sweden; however, export of these exchanges is unknown.

(U) Twelve of the estimated 15 tertiary (3rd level of hierarchy) offices in the Soviet Ministry of Communications (MOC) network have been identified as Ericsson ARM-20 systems; the others have not been identified. The ARM-20 is a crossbar switch which may have been updated with SPC control and is manufactured by Ericsson of Sweden and Ericsson's Yugoslavian licensee, Nikola Tesla, and probably by its Hungarian licensee, BHG, between 1976 and 1980. The secondary offices, between 150 and 170 in the MOC network, are mainly systems of the Soviet designed AMTS, an analog, space division switching system.

(FOUO) Bulgaria issued a tender for bids to supply digital switching systems to the WP in 1983. Major contenders for the sale were NEC (NEAX-61) and Plessey/GEC (System X). Both bidders dropped their offers in July 1984.

(FOUO) Hungary issued a bid for tenders for digital switching systems and manufacturing technology in May 1981. Northern Telecom withdrew their bid in 1983, apparently for technical reasons. Ericsson also withdrew their bid in 1984 because it was unable to obtain a US export license for components of its AXE system. Hungary signed a letter of intent with Standard Elektrik Lorenz (SEL), ITT's West German subsidiary, to purchase System 12 equipment and manufacturing technology in 1984. Although SEL's bid was withdrawn, discussions were held with the Hungarians in November 1984.

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2.c. Domestic Production of SPC Switches (U)

(U) Due to the Soviets' inability to produce or import sophisticated electronic SPC switches, they have focused on the development of quasielectronic switching systems which employ an intermediate level of technology. Without the transfer of microelectronic know-how from the Free World, the Soviets would not have been able to indigenously produce fully electronic switches in the near future.

(U) In the 1981-1985 period, the Soviet plan called for the introduction of domestic quasielectronic switching systems into the UACS. These systems were the KVANT, KVARTS, and ISTOK which are space-division, quasielectronic exchanges. Hardware for these systems was displayed at the International Exhibition Svyaz '81 in Moscow.

(S-NF-WN) The Soviets have purchased a Metaconta 10-C system manufactured by ISKRA of Yugoslavia under license from the Bell Telephone Manufacturing Company (a Belgian subsidiary of the US firm ITT). The 10-C is a quasielectronic SPC switch. The Soviets had planned to install additional Metaconta 10-C systems in Alma Ata, Novosibirsk, Kaliningrad, Krasnodar, and Gomel.

(U) Analysis indicates a new version of the Metaconta 10-C, the Metaconta 10-CN, another quasielectronic SPC switching system produced by ISKRA of Yugoslavia, has been installed at Yerevan, Armenia. This would be the first installation of the Metaconta 10-CN in the USSR. It was scheduled to become operational during the first quarter of 1983. Additional exchanges of this type were planned for installation at Minsk, Kiev, and Gurzuf.

(U) In 1983, the Soviets indicated that the available SPC electronic and quasielectronic long-distance exchange technology satisfied the switching requirements of the Unified Automated Communication System (UACS). They also stated that the installation of these systems would enable the wide-scale application of a future common-channel, single-frequency signaling system in communications between long-distance exchanges and national level automated transit switching control centers (UAK) operating under stored program control.

(C-WN) The acquisition of SPC switching technology has permitted the Soviets to initiate the installation of a series of diagnostic systems called Avtometizatsiy Sistemy Operativna-Tekhnicheskogo Obsluzhivania (ASOTO) for automated network supervision. These systems employ SPC equipment that will allow centralized monitoring and automated diagnosis of problems and malfunctions in the switching systems and network circuits. Such equipment provides early detection of problem areas so that critical traffic can be routed through alternative switches and circuits in the network. Experimental versions of ASOTO-type equipment are undergoing tests in Kiev and Petrozavodsk, USSR.

3. Technology Available for Future Transfer (U)

(U) An audit trail of switching systems imported into the USSR, dating back to the 1930's, reveals that the Soviets have had a long-term appreciation of

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technology transfer as an effective means of acquisition to satisfy their evolving switching requirements. As shown in Table I, the Soviets began importing large numbers of crossbar switches in the late 1960's to support their local and long distance exchange upgrades. It is clearly evident that Ericsson of Sweden has been the cornerstone for transfer of the rotary and crossbar switch technology which is widely used in Soviet contemporary networks. However, the scope of Soviet technology transfer program was expanded in the late 1970's because of the impact of the technological revolution in Free World semiconductor technology.

(U) Although microelectronics plays an important role in nearly all communications systems, its role is more critical in electronic switching and multiplexing. Without the use of integrated circuits the high-speed processing and custom circuits needed to provide the speed and diversity of services could not be achieved. Microelectronics also allows equipment size and weight to be reduced, but more importantly, it gives the equipment the features and reliability needed in today's systems.

(U) The evolution of microelectronics in the Free World has permitted the development of quasielectronic and electronic SPC switches which are critical elements in the WP plans to upgrade their network architecture and structure to fulfill their plans for an IDN. The WP countries, however, have been lagging the Free World in their ability to cost-effectively manufacture microelectronic components of sufficient quality and quantity to satisfy their evolving SPC switching requirements. Therefore, the WP countries, as orchestrated by the Soviets, have expanded their scope of switching acquisition to obtain SPC switching technology via licenses as well as direct purchases. SPC switching systems and technology have been obtained in the past from

- L. M. Ericsson of Sweden, and its licensee, Teslar
- CIT Alcatel* of France
- Iskra, a licensee of Bell Telephone Manufacturing Company (ITT) of Belgium
- Telenokia of Finland
- Thompson CSF of France*

Other companies, such as NEC of Japan, represent potential sources for SPC switching technology transfer.

(S) The WP countries will continue to use these avenues of technology transfer for SPC switching into the 1990's with emphasis on full-scale automation, integration, centralized control of networks, and the evolution of integrated digital networks. During this phase of the program, the WP countries will be faced with requirements to upgrade their SPC switches based upon the requirements of common-channel signaling, network control nodes, and network maintenance and management functions.

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TABLE I

SWITCHING EQUIPMENT IMPORTED INTO THE USSR (U)

DATE	TECHNOLOGY	PURPOSE	NOMENCLATURE	SOURCE
1930	Rotary	Local telephone exchange	AGF	Ericsson, Sweden
1957	Crossbar	Local telephone exchange	ARF	Ericsson, Sweden
1960	Crossbar	Local telephone exchange	ATSK-10,000	Tesla, Czechoslovakia, East Germany, USSR
1960	Ten-step (Strowger)	Local telephone exchange	ATS-54	East Germany
1963	Crossbar	Local telephone exchange	ATDK-55	Yugoslavia
1968	Crossbar	Local telephone exchange	ARK-300	Yugoslavia Licensed by Ericsson, Sweden
1968	Crossbar	Local telephone exchange	ARK-50	Ericsson, Sweden
1968	Crossbar	Local telephone exchange	ARK-522	Tesla, Czechoslovakia
1968	Crossbar	Local telephone exchange	ATS-K	Tesla, Czechoslovakia
1970	Crossbar	Local telephone exchange	ARF-10	Ericsson, Sweden
1970	Crossbar	Long distance transit telephone exchange	ARM-201/2	Ericsson, Sweden
1970	Crossbar	Long distance transit telephone exchange	ARM-201/4	Ericsson, Sweden
1970	Crossbar	Long distance transit telephone exchange	ARM-50	Ericsson, Sweden
1971	Crossbar	Long distance transit telephone exchange	ARM-20	Ericsson, Sweden

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TABLE I (Cont)

SWITCHING EQUIPMENT IMPORTED INTO THE USSR (U)

DATE	TECHNOLOGY	PURPOSE	NOMENCLATURE	SOURCE
1971	Crossbar	Local telephone exchange	ARF	Ericsson, Sweden
1976	Crossbar	Local telephone exchange	AST-K60	Nikola Tesla, Yugoslovia
1976	Crossbar	Local telephone exchange	AST-K60D	Nikola Tesla, Yugoslavia
1976	Crossbar	Local telephone exchange	AST-K60R	Nikola Tesla, Yugoslavia
1977	Crossbar	Long distance telephone exchange	AMTS-4	Tesla, Czecho-slovakia
1978	SPC-quasi-electronic	Long distance telephone exchange	Metaconta 10-C	ISKRA, Telecomm. Yugoslavia Licensed by Bell Mfg. Co. (ITT). Belgium
1980	Crossbar	Local telephone exchange	Pentakonta PC1000C	TELKOM-ZWUT, Poland, Licensed by CGCT (ITT), France
1983	SPC-electronic	Long distance telephone exchange	MT-20	Thomson-CSF*, France
1983	SPC-electronic	Local telephone exchange	DX-200	Telenokia, Finland

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(S) The WP countries have a cooperative program under a CEMA agreement to advance their domestic manufacturing capability of electronics. Although they appear to be making significant advances, their extensive demands for SPC switching cannot be accommodated in the foreseeable future by domestic production. Therefore, technology transfer will continue to be focused on direct and indirect acquisition of advanced microelectronics and associated manufacturing equipment for SPC switching. The Soviets cannot improve their manufacturing capabilities by reverse engineering state-of-the-art switches acquired through direct purchases; the problem remains their inability to mass produce microelectronic components, not in designing the switches. Reverse engineering of SPC switches is difficult because of the difficulty in copying software

(U) Table II shows the major manufacturers of digital, time division SPC switching systems, the dates the systems were introduced, and their advertised maximum line and busy hour call attempts (BHCA) capacities. These manufacturers represent possible sources of advanced switching equipment for the WP. High development costs and the competitive marketplace account for the trend toward forming joint ventures, such as the Phillips/AT&T venture, the Italtel/GTE venture, the Plessey/GEC venture, and the CIT-Alcatel/Thomson* venture shown in Table II. Some estimates suggest that the current world market will support only three switch manufacturers, and further industry consolidation should be anticipated.

(U) The numbers shown are advertised maximum capacities; systems may be configured to serve a smaller number of lines and to provide lower BHCA capacities.

3.a. Licensing of Technology to Non-COCOM Countries (U)

(U) Both COCOM and non-COCOM manufacturers are transferring switching technology outside their host countries. Table III lists these manufacturers and the countries involved in the transfer. Digital, time division SPC switching technology is being transferred through licensing agreements and subsidiaries to Taiwan, India, Israel, and South Africa, as well as to other non-COCOM countries. Such widespread technology transfer is indicative of the highly competitive world market, where purchasers are able to require some degree of local manufacture or assembly of components as part of the contract. The large numbers of licensing agreements also reflect the desire of most countries to have a domestic telecommunications manufacturing capability because of the strategic military importance of communications.

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TABLE II

MAJOR DIGITAL, TIME DIVISION, STORED PROGRAM CONTROLLED CENTRAL OFFICE SWITCHING SYSTEMS (U)

Country	Company	System	Year Introduced	Advertised Maximum Capability[1] Lines	Trunks	BHCA[2]
COCOM						
Belgium	ITT	System 12 (1240 switch)	1980	100,000	60,000	750,000
Canada	Northern Telcom	DMS 10	1977	na	na	36,000
		DMS 100	1979	100,000	60,000	300,000
France	CIT-Alcatel/Thomson[4]	E-10B[3]	1970	45,000	11,500	200,000
		E-10S	Unknown	25,000	2,000	120,000
		MT-20	1979	na	na	na
F.R. Germany	Siemens	EWSD	1980	100,000	60,000	750,000
Italy	Italtel/Telettra	Proteo	1978	na	na	na
		UT10/3	1980	20,000	4,000	120,000
		GTD-5C	1984	145,000	48,000	na
Japan	Fujitsu	Fetex 150	Unknown	240,000	60,000	700,000
	Hitachi	HDX 10	1981	240,000	60,000	720,000
	NEC	NEAX 61	1979	100,000	60,000	700,000
Netherlands	Philips/AT&T	ESS-5/PRX	1984	150,000	60,000	500,000
United Kingdom	Plessey/GEC	System X	1980	na	60,000	500,000

1 - The data is intended to provide measures of switch capabilities and not a list of present characteristics of these products.

2 - BHCA = busy hour call attempts.

3 - Digital system without stored program control.

4 - Now part of the French firm Alcatel, which is composed of CIT-Alcatel and Thompson CSF.

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TABLE II (Cont)

MAJOR DIGITAL, TIME DIVISION, STORED PROGRAM
CONTROLLED CENTRAL OFFICE SWITCHING SYSTEMS (U)

				Advertised Maximum Capability		
Country	Company	System	Year Introduced	Lines	Trunks	BHCA
United States	AT&T	ESS-4	1976	na	40-50K trunks	700,000
		ESS-5[5]	1980	60,000	15,000	150,000
	GTE	GTD-5EAX	Unknown	145,000	48,000	360,000
Non-COCOM						
Finland	Telenokia	DX-200	1982	40,000	7,000	100,000
Sweden	Ericsson	AXE-D	1977	200,000	65,000	800,000[6]
Yugoslavia	Iskra	SI 2000	na	-	-	-

[5] - AT&T has under development a new version of the No. 5 ESS with a capacity of 100,000 lines, 50,000 trunks, and 500,000 BHCA.

[6] - These figures are for the APZ 212 computer -- with APZ 211, BHCA capacity is 150,000.

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TABLE III

TECHNOLOGY TRANSFER TO
NON-COCOM SUBSIDIARIES AND LICENSEES (U)

COMPANY	COUNTRY	SUBSIDIARY/LICENSEE	MANUFACTURER
A. COCOM MANUFACTURERS			
AT&T -ESS-5	Taiwan	Directorate Gen. Telecom./Bank of Communications	Unknown
CIT-Alcatel/ Thomson* -- E-10B	India	Indian Telephone Industries	Future
	Ireland	Alcatel Ireland	Yes
	Pakistan	Potential (Entity not named.)	Future
	South Africa	Altech Ltd.	Yes
-- MT-20	USSR	Unknown	Yes
GTE -- GTD5	Taiwan	GTE Taiwan Telecom.	Yes
	Yugoslavia	Electronska Industrija	Future
ITT -- System 12	Austria	ITT Austria/ Siemens Osterreich	Future
	Finland	ITT/SEP	No
	Republic of Korea	KETRI	Future
	Mexico	Indentel	Future
	PRC	Potential Shanghai Bell Telephone Manufacturing Co.	Future
	Spain	Standard Electrica SA	Yes

NOTE: This is only a partial list.
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TABLE III (Cont)

TECHNOLOGY TRANSFER TO
NON-COCOM SUBSIDIARIES AND LICENSEES (U)

COMPANY	COUNTRY	SUBSIDIARY/LICENSEE	MANUFACTURER
ITT -- System 12 (Cont)			
	Switzerland	Standard Telefon and Radio	Future
	Taiwan	Potential - TAISEL	Future
	Yugoslavia	ISKRA	Future
Northern Telcom -- DMS-100	Austria	Kapsch/Schrack Elektronik AG	Future
	Israel	Telrad	Yes
Siemens - EWSD	Argentina	Siemens SA	Yes
	Bangladesh	POTENTIAL - Telephone Shilpa Sangstha	Future
	Finland	Siemens Usakeyhtio	Unknown
	South Africa	Siemens SA/TEMSA	Unknown
	Switzerland	Siemens-Albis	Future
B. NON-COCOM MANUFACTURERS			
Ericsson -- AXE	Australia	Standard Tel. & Cables L. M. Ericsson Pty. Ltd.	Yes
	Brazil	Ericsson do Brasil	Yes
	Colombia	Ericsson de Colombia	Yes
	Finland	OY L. M. Ericsson Ltd.	Yes
	Ireland	L. M. Ericsson Ltd.	Yes

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TABLE III (Cont)

TECHNOLOGY TRANSFER TO
NON-COCOM SUBSIDIARIES AND LICENSEES (U)

COMPANY	COUNTRY	SUBSIDIARY/LICENSEE	MANUFACTURER
B. NON-COCOM MANUFACTURERS (Cont)			
	Republic of Korea	Oriental Telecommmunications Co. (OTELCO)	Future
	Malaysia	Pewira Ericsson SDN BHD	Future
	Mexico	Teleindustria Ericsson	Yes
	Saudi Arabia	Unknown	No
	Spain	Industrias de Telecomunicacion SA	Yes
	Switzerland	Hasler AG/Ericsson AG	Future
	Yugoslavia	Nikola Tesla	Yes

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(U) Transfer of switching technology includes the technology associated with the design of the system architecture and controlling computers, the computer programming, and the microcircuitry involved. A number of these agreements are for the design and production of the interfaces between the main switch and the telephone network. While the central control does not have to be modified for each country's network, the interface units do. Therefore, the major manufacturer might supply the central control, while the licensee would produce the interface equipment.

(FOUO) Descriptions of licensing agreements with non-COCOM countries are summarized in Table IV. The table shows the licensing company, the affiliated countries, and descriptions of the agreements.

3.b. Developing Countries (U)

(U) Brazil, the Republic of Korea, and Yugoslavia are developing their own digital, time division SPC switching systems. All of these systems are quite small and are on the lower end of the technology spectrum. However, they do represent an ever-expanding technological capability worldwide.

4. Conclusions (U)

4.a. Summary of Foreign Availability (U)

(C) Analysis indicates that despite widespread licensing of telecommunication technology to non-COCOM countries, such countries should not be a major source of COCOM controlled switching technology for the USSR over the next few years. Production by licensees mainly supplies domestic telecommunications administrations. Although three developing countries are testing their own small exchanges, these countries have not yet achieved serial production, and can be discounted as non-COCOM suppliers to the WP for the next few years.

(S-NF) Telenokia is apparently selling its DX-200 to the Soviets, and the French MT-20 is being installed, probably from local production. There also are reports that CIT-Alcatel/Thomson* delivered MT-20 systems to Bulgaria before the 1988 COCOM restriction release date.

(C) Monitoring advance marketing and software development of the larger, more powerful systems such as the ITT System 12 and the Ericsson AXE would control future Soviet access to these systems. Because of their long history of technology transfer to the WP, monitoring Ericsson's licensees, particularly in Finland and Yugoslavia, may provide an indication of the Soviets' indigenous production deficiencies.

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TABLE IV

DESCRIPTIONS OF LICENSING AGREEMENTS WITH NON-COCOM COUNTRIES (U)

COMPANY	COUNTRY	DESCRIPTION OF AGREEMENT
AT&T	Taiwan	Transferred No.5 ESS technology to Directorate General of Telecommunications and Bank of Communications. First deliveries planned for 1986; local content to increase from 10% in 1986 to fully integrated production by 1988-1989. Some output to be exported.
CIT-Alcatel/ Thomson* -- E-10B	India	Indian Telephone Industries (ITI) to construct two plants, one with an annual capacity of 500,000 lines of local exchange equipment, the other with an annual capacity of 30,000 lines of trunk equipment. Both plants are to begin production in 1985-1986. India to import 200,000 lines of E10B equipment from France before local production begins. Some difficulty in interfacing French equipment with Indian telephone network experienced in 1984. Indian market for electronic switches estimated to be 5 million lines over 1985-1990 period.
	Ireland	Plant built to produce 47 E10B systems for Irish PTT - began operation in 1982. CIT-Alcatel/ Thomson parent company to buy back 40% of output of Irish plant.
	Pakistan	Contract reported September 1984; plant to be set up within one year. Equipment produced ultimately to have 70% local content.

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TABLE IV (Cont)

DESCRIPTIONS OF LICENSING AGREEMENTS WITH NON-COCOM COUNTRIES (U)

COMPANY	COUNTRY	DESCRIPTION OF AGREEMENT
Ericsson AXE	Australia	Total of 475,000 lines on order by national telephone company. Manufacture by Ericsson subsidiary and, from mid-1985, by STC (UK) subsidiary under license.
	Brazil	First AXE installed April 1984; plant capacity of 260,000 lines per year. Exports to Uruguay reported.
	Colombia	"Certain" local manufacture. As of January 1984, Ericsson reported 133,000 local AXE lines in service and 215,000 on order, and 50,892 trunk lines in service and 40,444 on order.
	Republic of Korea	Joint venture with Oriental Precision Co., known as Oriental Telecommunications Co., or OTELCO. First plant to be in operation in March 1984, with annual capacity of 250,000 lines. Initial order by Korean Telecommmunications. Authority (1983) for 755,000 lines (20 exchanges) over the period 1984-1986.
	Malaysia	Agreement signed 1982. As of January 1984, Ericsson reported that Malaysia had 112,640 local AXE lines in service, 310,000 on order; had installed 5632 trunk AXE lines in 1983 and had 12,800 more on order. Whether these were manufactured in Malaysia is not known.
	Mexico	To date, Mexico has ordered 17 AXE exchanges, for 50,000 local and 22,000 trunk lines.
	Yugoslavia	Licensee Nikola Tesla has been manufacturing AXE exchanges with APZ 210 control. 1983 annual report stated that Nikola Tesla had manufactured 43 AXE exchanges for Yugoslavia and foreign markets.

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TABLE IV (Cont)

DESCRIPTIONS OF LICENSING AGREEMENTS WITH NON-COCOM COUNTRIES (U)

COMPANY	COUNTRY	DESCRIPTION OF AGREEMENT
ITT	Finland	No manufacturing, but technology transferred via SEP (subsidiary).
	Republic of Korea	No manufacturing, but technology transferred via KETRI for possible future production. No firm orders.
	Mexico	Technology transferred, but no manufacturing yet. Mexico has ordered 580,214 lines (350 exchanges).
	People's Republic of China	Technology transfer tabled indefinitely. Original plan called for production capacity of 300,000 lines per year; integrated circuit manufacturing facility also was planned.
	Spain	December 1983 report that Spanish orders totalled 1,126,110 lines (212 exchanges) through SESA (subsidiary).
	Switzerland	No manufacturing, but technology transferred via Standard Telefon and Radio (subsidiary). Swiss PTT has ordered total of 19,840 lines (2 exchanges).
	Yugoslavia	Agreement signed November 1983 -- Bell Telephone Manufacturing Co. (Belgium) to transfer know-how to ISKRA over 5-year period. Eventual production capacity of 230,000 lines per year. Yugoslav PTT has ordered 570,000 lines.
Northern Telecom	Austria	Kapsch and Schrack Elektronik are adapting DMS system to CEPT standards. Work began in 1981; first system installed in December 1983. Exports to other European countries (no proscribed) expected.

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TABLE IV (Cont)

DESCRIPTIONS OF LICENSING AGREEMENTS WITH NON-COCOM COUNTRIES (U)

COMPANY	COUNTRY	DESCRIPTION OF AGREEMENT
Northern Telecom (cont)	Israel	Telrad adapted DMS-10 and -100 to CEPT standards. Installation of "TMX-10" switches manufactured by Telrad began in 1981; 8 exchanges were installed by 1983. First "TMX-100" installed in December 1982; 400,000 lines are to be installed over 5 years (to 1988).
Siemens	South Africa	Long term order for 1,930,000 lines over 15 years from Department of Posts and Telecommunications. Export unlikely in the near term.

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4.b. Control of Switching Technology (U)

(U) SPC circuit switching terminal and transit exchanges are subject to COCOM general exceptions treatment (embargo) until 15 September 1988. After that date, certain models will be approved if they do not have the following capabilities:

- (U) multi-level call preemption;
- (U) common channel signaling;
- (U) adaptive routing (or algorithms that would permit a search for trunk circuit connection paths);
- (U) interconnection to multi-RF channel radio equipment for mobile use;
- (U) digital subscriber line interfaces;
- (U) digital synchronization circuitry for networking two or more exchanges;
- (U) centralized maintenance, including transmission of reception of instructions for controlling traffic, directionalizing paths, altering routing tables, connecting or disconnecting subscriber or trunk circuits, or managing the switch or network, except simple alarm routing to announce equipment malfunctions;
- (U) termination capacity of more than 50,000 lines or 13,000 trunks;
- (U) BHCA of greater than 225,000;
- (U) Erlangs greater than 5,000;
- (U) communications channels or terminal devices used for administrative control purposes that are not fully dedicated or that exceed a total data signaling rate of 9.6 thousand bits per second (kbps);
- (U) voice channels that exceed 3100 Hz.

(S-NF) The embargo has been effective, and if continued beyond the current termination date, September 1988, the impact on the WP would be even greater. Additionally, controls on general microelectronic production technologies, small-to-medium SPC transit switches and digital PABX technologies would further slow their advances.

(C) Microelectronics plays a critical role in the production of electronic switching systems. Without the use of state-of-the-art integrated circuits, the high-speed processing and custom circuits necessary to build SPC switches could not be achieved. Continuing the export controls on microelectronic technologies

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would severely inhibit the WP's ability to eventually produce sufficient quantities of their own fully electronic SPC switches.

(C) Control of small-to-medium SPC transit switches (under 20,000 trunks) would hinder Soviet plans to build a high-capacity, intelligent national network that can provide significant wartime command and control capability. These systems also have the potential to be used to build high-capacity dedicated networks to directly support daily military operations. The Soviets do not possess the indigenously developed technology to produce these systems, nor is there yet an abundance of foreign availability of such systems. The majority of the expertise with this technology lies within COCOM member countries.

(C) Control of sophisticated PABX systems, particularly technology for production, would significantly impact Soviet telecommunications plans. The Soviet intention to place PABXs in every organization with more than 50 phones would allow for more efficient use of their local exchanges. The Soviets will probably not be able to meet this demand without a large scale transfer of PABXs from the Free World. In addition to the efficiency that PABXs would bring to design bureaus and military manufacturing plants, they also have a high potential for dual military/civil use. Modern PABXs are small, versatile, and powerful. They can easily be converted for use in mobile or transportable military systems. A digital PABX can efficiently switch both digital and voice communications. This capability is extremely important in military command and control systems.

(C) Export controls on non-SPC switching systems used in local exchanges and PABXs will have little effect on Soviet command and control goals. Such systems are available from many sources and provide basic WP telephone service. Also, the control of conventional transmission systems, such as analog microwave and metallic cable systems, will not significantly affect the WP's military command and control capabilities.

(S-NF) The USSR and other WP countries realize that an efficient national telecommunications network is necessary for their long-term military strength and continued world influence. The Free World's control of SPC switching technology has limited the Warsaw Pact's ability to expand their national strategic switching systems and has thereby slowed their infrastructure upgrade. Soviet military switching needs have been partially met by using less sophisticated equipment, but control of the above mentioned systems will greatly hinder any future upgrades of their strategic military command and control systems.

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GLOSSARY OF SWITCHING TERMS (U)

(U) Common Channel Signaling -

A signaling system whereby all signaling for a number of voice paths is carried over one common channel, instead of within each individual channel.

(U) Concentrator -

A device, usually a switching stage, in which a number of input lines are connected to a smaller number of output lines.

(U) Crossbar Switch -

A space division switch in which a series of vertical and horizontal multiple contact relays are ganged together by metal bars to form a matrix. Typically, the horizontal bars perform the selection and the vertical bars hold the function to establish circuit paths between the row and column crosspoints of the matrix.

(U) Electronic Switch -

A switch which uses semiconductors in the control and matrix sections to establish circuit paths.

(U) Erlang -

The international dimensionless unit of traffic intensity. One erlang is the intensity in a traffic path continuously occupied, or in one or more paths carrying an aggregate traffic of 1 call-hour per hour, 1 call-minute per minute, and so on. Th aggregate traffic load offered to an exchange includes all the erlang capacities of subscriber and trunk lines.

(U) Frequency Division Multiplexing (FDM) -

A multiplexing technique for combining several inputs into one transmission path. The available frequency spectrum is divided into narrower bands, each used for a separate input.

(U) Pulse Code Modulation (PCM) -

A method of modulation in which a continuous analog wave is transmitted in an equivalent digital mode. The original analog signal is sampled at regular intervals, and the magnitude of each

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sample is quantized independently of other samples and converted by encoding to a digital signal, which may or may not be transmitted without additional modulation steps.

(U) Quasielectronic Switch -

A term of European origin applied to a space division matrix switch that operates under the control of an electronic device and uses mechanical contacts, usually reed relays, to establish circuit paths between the row and column of the matrix. The ESS-1, -2, and -3 are the corresponding US switching counterparts.

(U) Rotary Switch -

A switch in which a motor-driven rotating selector is used in conjunction with a system of clutches and locking pawls to connect a circuit path.

(U) Space Division Switching -

A technique in which switches construct a separate physical circuit path for each individual call end to end.

(U) Ten-Step Switch -

A step-by-step, relay operated, space division, rotary switch commonly referred to as a Strowger switch. The modern basic switch is usually made up of 10 parallel sections with 10 contacts in each section. Thus, it is often called a decade selector.

(U) Time Division Multiplexing (TDM) -

A multiplexing technique for combining several inputs into one transmission path. Each input is allotted a specific position in the signal stream, based upon time. Thus, the information from each input line is interleaved, forming a higher speed main channel.

(U) Trunk -

A telephone circuit or channel between two switching exchanges.

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